MI-0032

DYMANIC APERTURE WITH γt JUMP

ROD GERIG

Dynamic Aperture with γ_t Jump

Rod Gerig
Main Injector Department
Fermi National Accelerator Laboratory
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1 Introduction

Problems associated with transition crossing are still being addressed in the design of the Main Injector. One technique for dealing with the effects of transition crossing is to pulse quadrupoles in such a way as to quickly lower the transition energy, and thus pass through transition more rapidly. A scheme for doing this is discussed in MI note $MI-0008$ by Steve Holmes. However, this scheme introduces some problems of its own. In order to effect the transition energy the dispersion function must be modified, and in this design the peak values of the dispersion function are around 7 meters.

This MI note discusses dynamic aperture simulations which were performed on the mi_15 lattice design with a γ_t jump. The technique used is almost identical to that presented in $MI-0008$ but in fact was found independetly by the author of this note. However the number of quadrupoles, their strengths, and the resulting dispersion wave are similar. Figure 1 shows the horizontal beta function and the dispersion function. This data was generated by tevlat, the program also used to do the tracking.

2 Nonlinearities

Transition is a particularly bad time for a number of reasons. In addition to the problems associated with η going to zero and flipping the phase of the rf, it also happens to be the time that the eddy current multipoles have the greatest effect on the beam. The eddy current multipoles will have their greatest effect when the quantity $\dot{P}/P$ is at a maximum. In a ramp where transition occurs within the first parabolic section, the maximum $\dot{P}/P$ will be at twice the injection momentum. In the Main Injector this will be at 17.8 GeV/c, very close to transition. In MI note MI-0026 I looked at the amount of sextupole coming from all sources, and found that at transition there is about 4.5 units (at 1 inch). In the tracking a larger value of around 8 units was used so that these results are conservative. Recent calculations by Francois Ostiguy suggest that higer order multipoles arising from eddy current effects are negligable.[1] At any rate, they were not included.

[1] These results are presently unpublished.

In each case I used the anticipated chromaticity correcting sextupoles to correct the chromaticity to less than ± 1 unit.

3 Tracking

In determining the dynamic aperture at transition, different assumptions are made than at other portions of the accelerating cycle. The synchrortron oscillation frequency is so low that none was included in the simulation. In each case the particle was given the maximum anticipated $\Delta P/P$ of .5%. The time region over which $\Delta P/P$ gets large is 10 msec (1000 turns). My feeling is that these conditions represent a situation less favorable to particle survival than what will actually be encountered by the beam. As the work of understanding transition proceeds, the choice of these numbers may need to be reinvestigated.

4 Results

Tracking scans were done beginning at an horizontal amplitude of 15 mm. This corresponds to a single particle emittance of around $78\,\pi\, mm - mrad$ normalized. The amplitude in the vertical plane was for the same emittance. The step size was .01 mm in the horizontal plane. No particles were ever lost. Different paths were taken toward the center of phase space, but the results were the same in each case.

5 Conclusions

There is no evidence that there will be particle loss, or emittance growth due to dynamic aperture effects at transition in the presence of a γ_t jump. It should be noted, however, the overall physical beam size will be quite large. A particle with an emittance of 30π mm-mrad and a $\Delta P/P$ of $\pm.5\%$ will be ± 45 mm from the closed orbit. This implies that closed orbit control will be extremely important during transition.

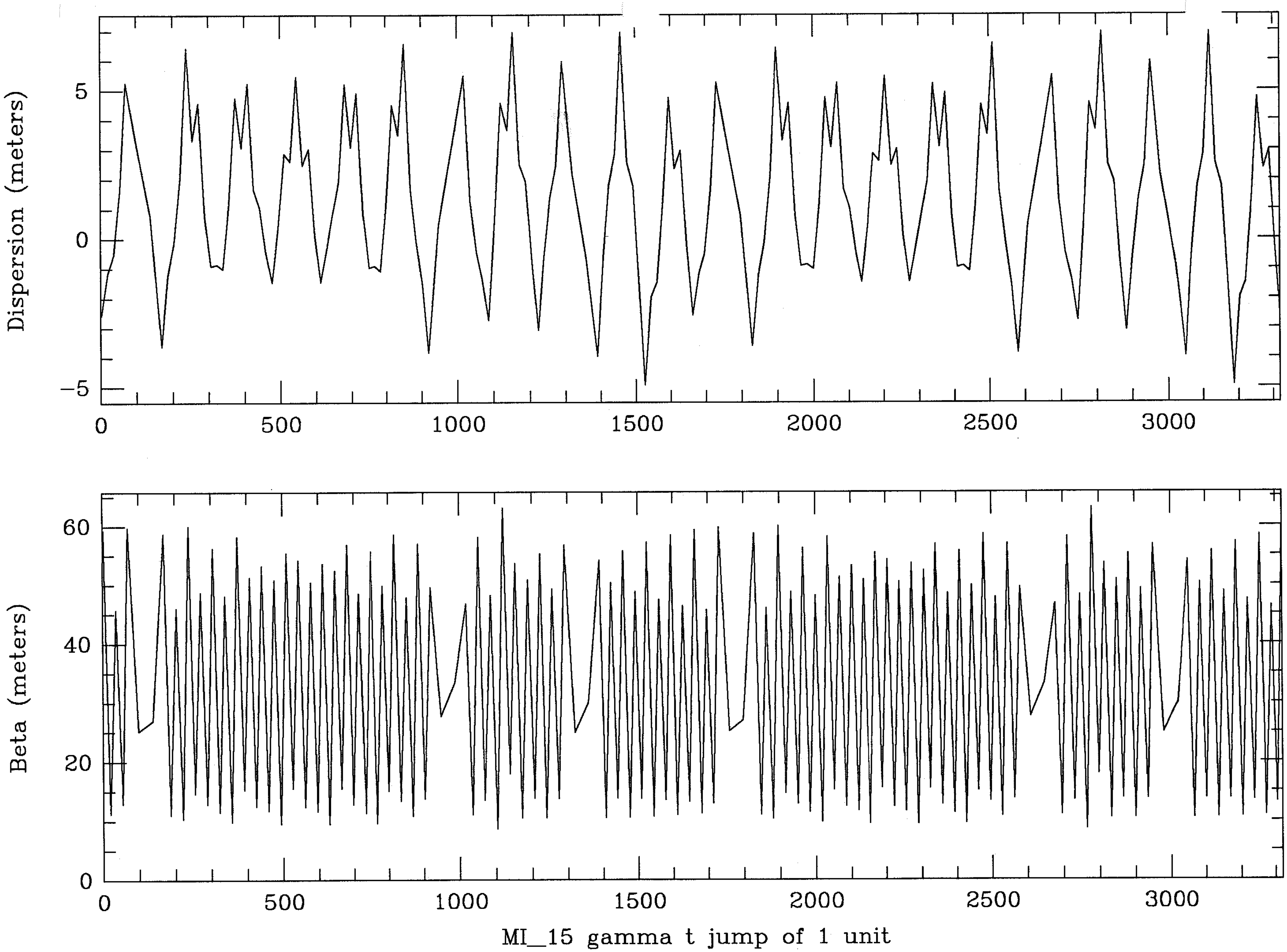
Dispersion (meters)
5
0
−5
0
500
1000
1500
2000
2500
3000
Beta (meters)
60
40
20
0
0
500
1000
1500
2000
2500
3000
MI_15 gamma t jump of 1 unit

Figure 1